Photon study progress and $H \to \gamma\gamma$ benchmark

CEPC Physics Performance Wednesday Working Meeting

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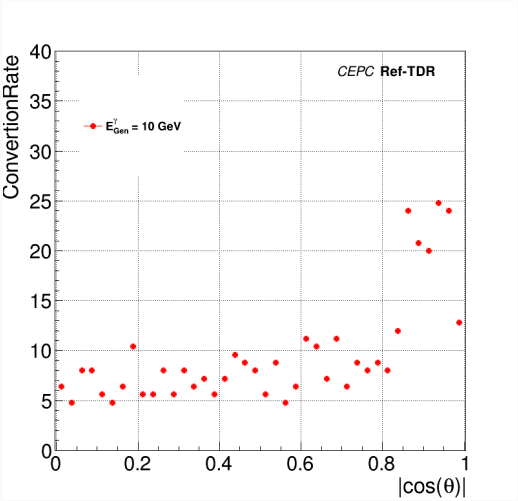
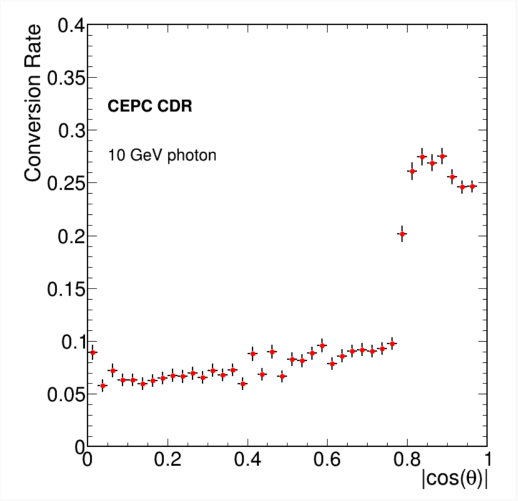
Progress

-Differential distribution plots for Ref-TDR: Energy Resolution, Convertion Rate & Efficiency (relative to Truth Photon Energy and $cos(\theta)$)

-Truth distributions from latest Pythia generated samples for $e^+e^- \rightarrow qq(\gamma\gamma)$

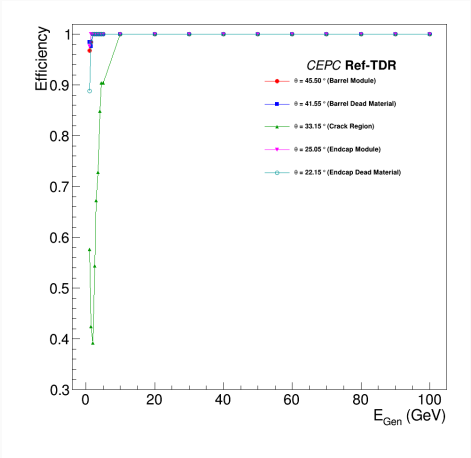
Convertion Rate

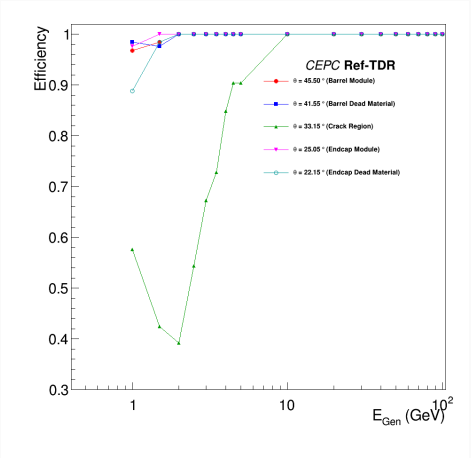




For the convertion rate, the results are pretty similar to those from the CDR with the barrel ($|cos(\theta)|<0.8$) around 6-8% and the endcap ($|cos(\theta)|>0.8$) reaching 25%

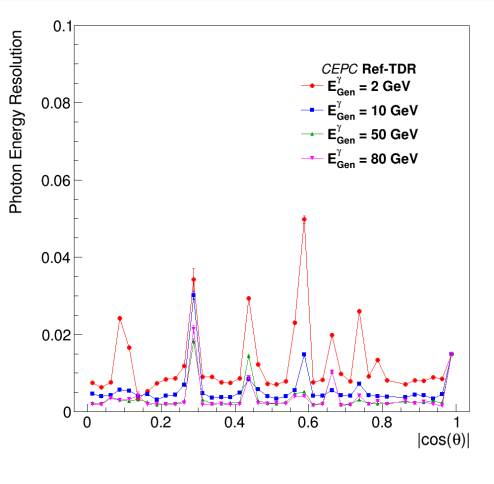
Efficiency





The efficiency of reconstruction is mostly worse (less than 100%) for low energies (1 & 1.5 GeV) except in the crack region between barrel and endcap where it only reaches 100 % at 10 GeV

Energy Resolution per $cos(\theta)$



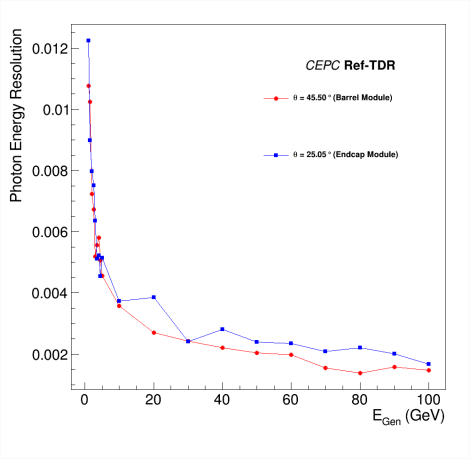
*$|cos(\theta)|$=0.8375: Crack region between barrel and endcap showing strange behavior : Not shown in plot

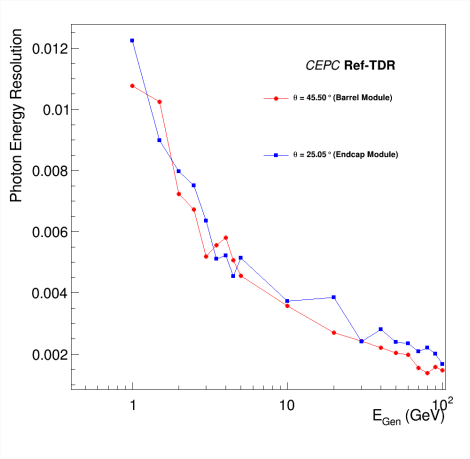
*Not big difference between barrel and endcap modules resolution

*Outer points in dead material (cracks between 2 modules)

*Lowest energies give worse resolution

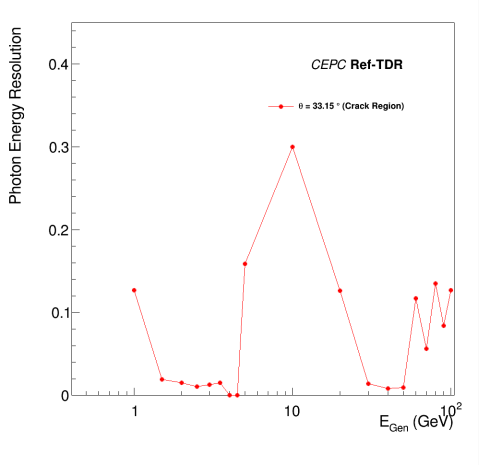
Energy Resolution per E_{gen}





-Reconstruction in barrel and endcap similar (less than 1%) within the module

Energy Resolution per E_{gen} within crack region



-Crack region results not pertinent (strange behavior, no peak)

Background generated sample with Pythia

For the $H \to \gamma\gamma$ analysis, one of the main backgrounds with most contribution is $e^+e^- \to qq(\gamma\gamma)$

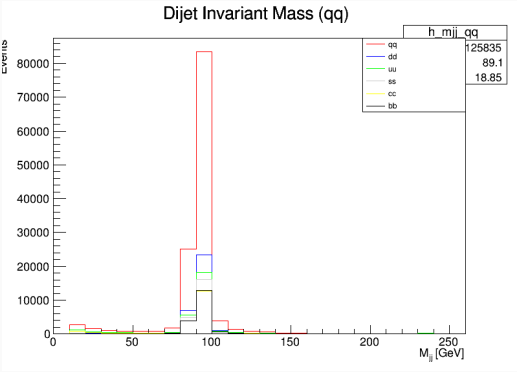
Using Pythia and linking it with Delphes for fast simulation, we are looking to simulate events for this background while applying a condition on diphoton invariant mass $m_{\gamma\gamma}$>90 GeV

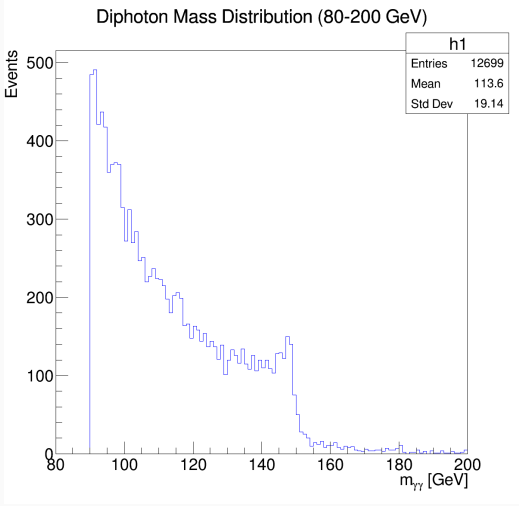
In Pythia, the process is $e^+e^- \to Z^0/\gamma \to qq(\gamma\gamma)$ (ffbar2gmZ) with photons in final state coming from ISR & FSR

```
// Generator setup
Pythia pythia;
pythia.readString("Beams:idA = 11");
pythia.readString("Beams:idB = -11");
pythia.readString("Beams:eCM = 240");

// Enable e+e- -> gamma*/Z -> qqbar process.
pythia.readString("WeakSingleBoson:ffbar2gmZ = on");
pythia.readString("23:onMode = off");
pythia.readString("23:onIfAny = 1 2 3 4 5");
pythia.readString("22:onMode = off");
pythia.readString("22:onIfAny = 1 2 3 4 5");

// Enable ISR, FSR, and QED showers.
pythia.readString("PartonLevel:ISR = on");
pythia.readString("PartonLevel:FSR = on");

// Initialize LHE output
LHAupFromPYTHIA8 myLHA(&pythia.process, &pythia.info);
myLHA.openLHEF("CEPCZRR_filtered.lhe");

// Initialize Pythia
if (!pythia.init()) return 1;

myLHA.setInit();

int nEvents = 100000;
int nFiltered = 0;
```

```
// Event loop
for (int iEvent = 0; iEvent < nEvents; ++iEvent) {
    if (!pythia.next()) continue;
    myLHA.initLHEF();

    // Find photons in the event
    std::vector<int> photonIndices;
    for (int j = 0; j < pythia.event.size(); ++j) {
        if (pythia.event[j].id() == 22 && pythia.event[j].isFinal()) {
            photonIndices.push_back(j);
        }
    }

    // Require at least two photons
    if (photonIndices.size() < 2) continue;

    // Loop over photon pairs to calculate mass
    bool passMassCut = false;
    for (size_t j = 0; j < photonIndices.size(); ++j) {
        for (size_t k = j + 1; k < photonIndices.size(); ++k) {
            Vec4 p4_1 = pythia.event[photonIndices[j]].p();
            Vec4 p4_2 = pythia.event[photonIndices[k]].p();
            double mDiphoton = (p4_1 + p4_2).mCalc();

            if (mDiphoton > 98.0) {  // Apply mass cut
                // Store the mass in the file
                outFile << mDiphoton << std::endl;
                myLHA.setEvent();  // Store event in LHE file
                myLHA.eventLHEF();
                nFiltered++;
                passMassCut = true;
                break;
            }
        }
        if (passMassCut) break; // Exit outer loop once a valid pair is found
```

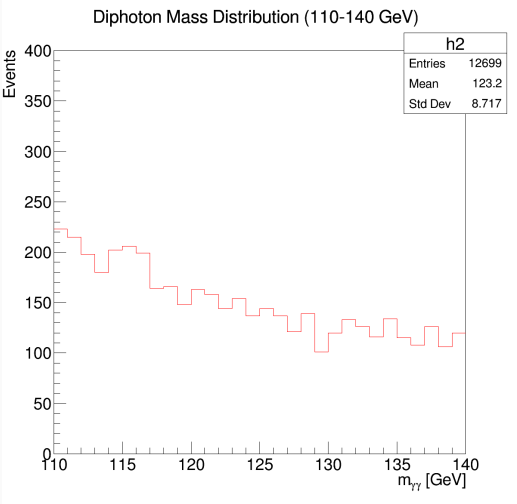
Truth Distributions

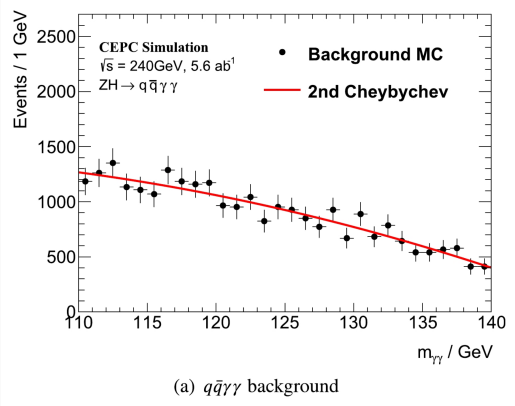




Checking the dijets and diphoton distribution to see if any cut has been applied (cut on diphoton invariant mass wanted)

Truth Distribution





(a) $q\bar{q}\gamma\gamma$ background

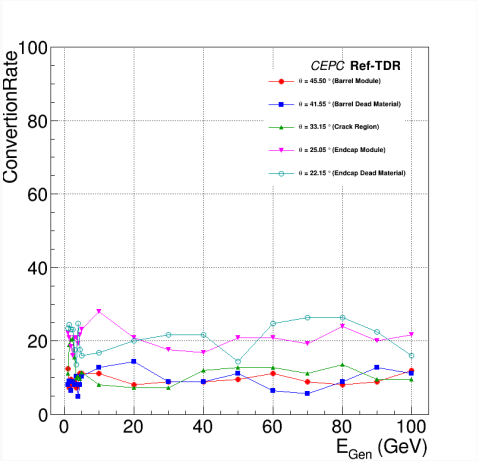
Applying another cut on our diphoton distributions, we found a shape similar to the one(reco) from the CDR analysis that could be fitted using a 2^{nd} order Chebyshev fit

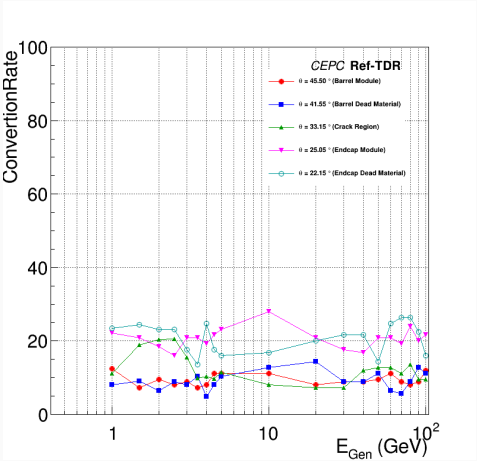
Thank you!

Back-up

Back-up

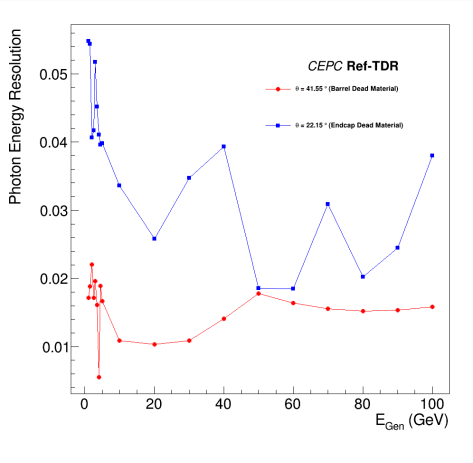
Convertion rate per E_{gen}

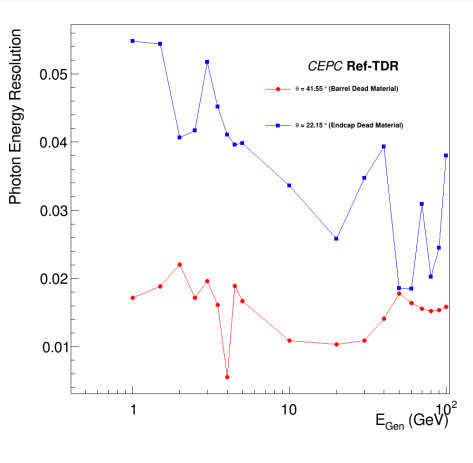




Back-up

P.E.R. per E_{gen} for dead material (both barrel & endcap)

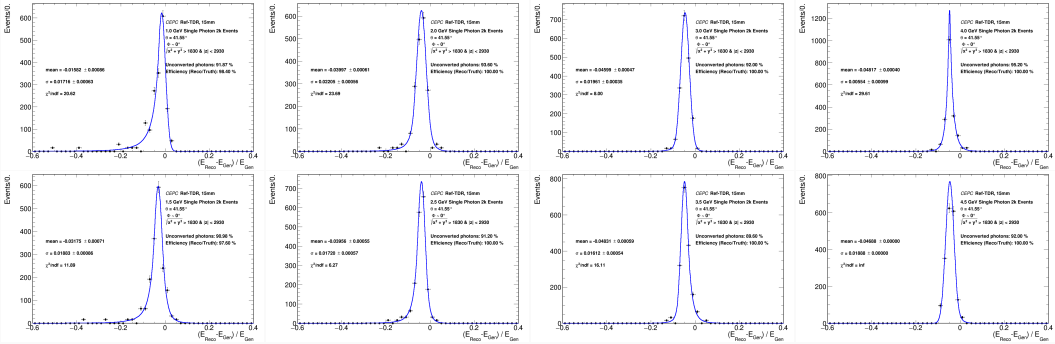




Few points can be better fitted (maybe with more data) but fit is not only problem

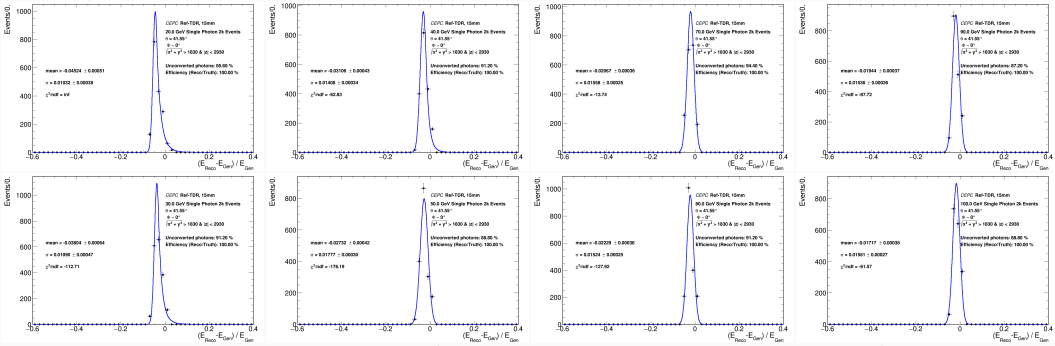
Back-up

Barrel dead material (Crack $\theta = 41.55°$)



Back-up

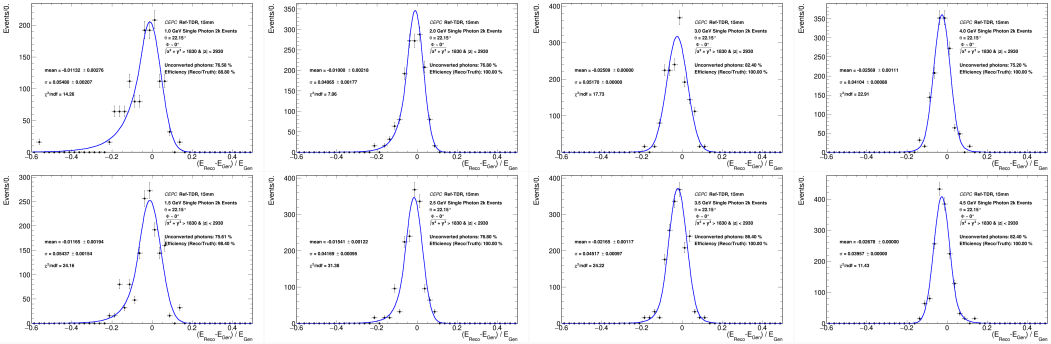
Barrel dead material (Crack $\theta = 41.55°$)



Very few points have problems in fit (lack of data, or just fit not well tuned) but for most points, good fit yet no specific trend with evolution of energy

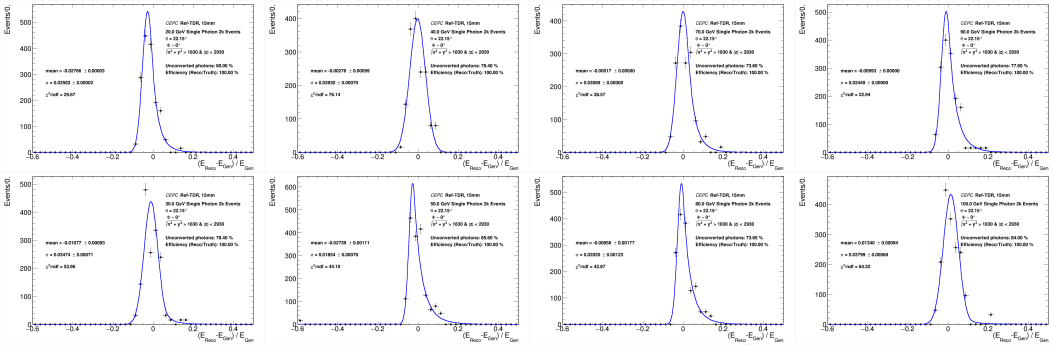
Back-up

Endcap dead material (Crack $\theta = 22.15°$)



Back-up

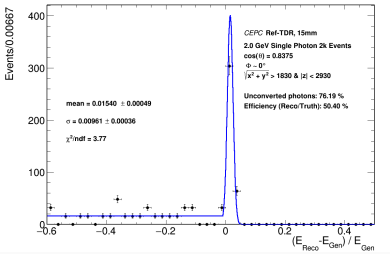
Endcap dead material (Crack $\theta = 22.15°$)

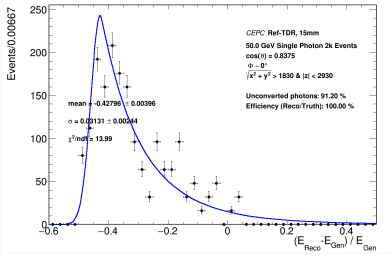


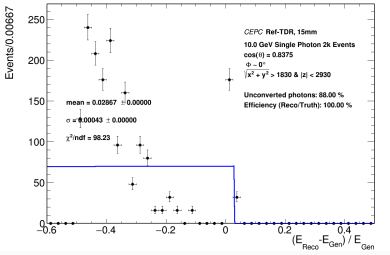
Same matter as for barrel but with much worse reconstruction (unexpected from software team, expectation: similar and much closer curves)

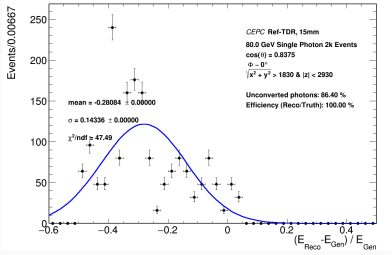
Back-up

*Strange behavior for |cos(θ)|=0.8375: Crack region between barrel and endcap (no peak)



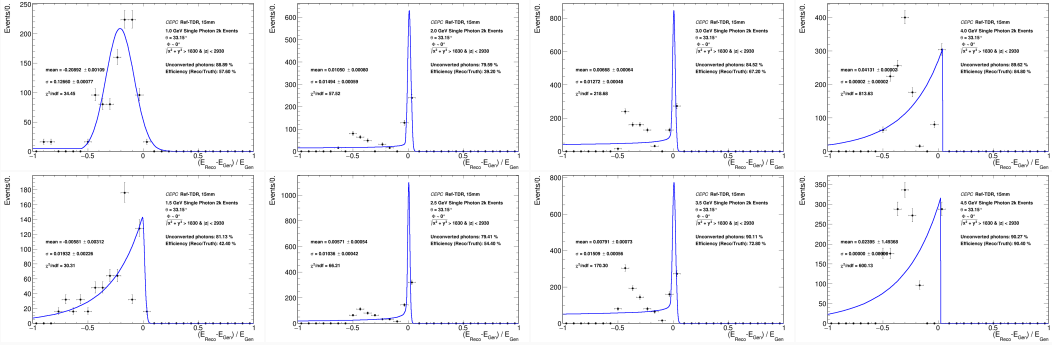






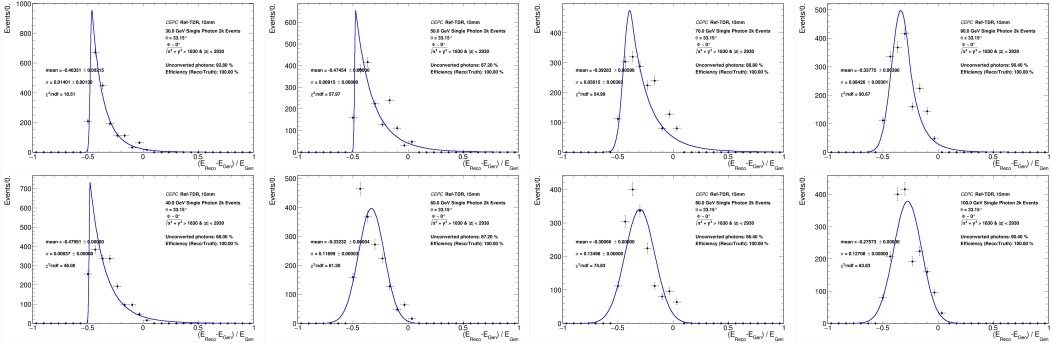
Back-up

Crack region through small energies (1-4.5 GeV)



Back-up

Crack region through mid to high energies (30-100 GeV)



Weird behavior expected, bad reconstruction